Forecasting at the interface between weather and climate: beyond the RMM-index

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OUTLINE…

- The Global Tropics Hazards and Benefits Outlook (GTH)
- The DYNAMO campaign
- The NCEP models during DYNAMO
- Conclusions and future directions

Tropical Subseasonal Variability

Weather forecasting

Modulation of Tropical Cyclone probability of formation

Extreme precipitation events in the western CONUS

Seasonal to Interannual forecasting

Affecting predictability of ENSO

Modulating amplitude of ENSO

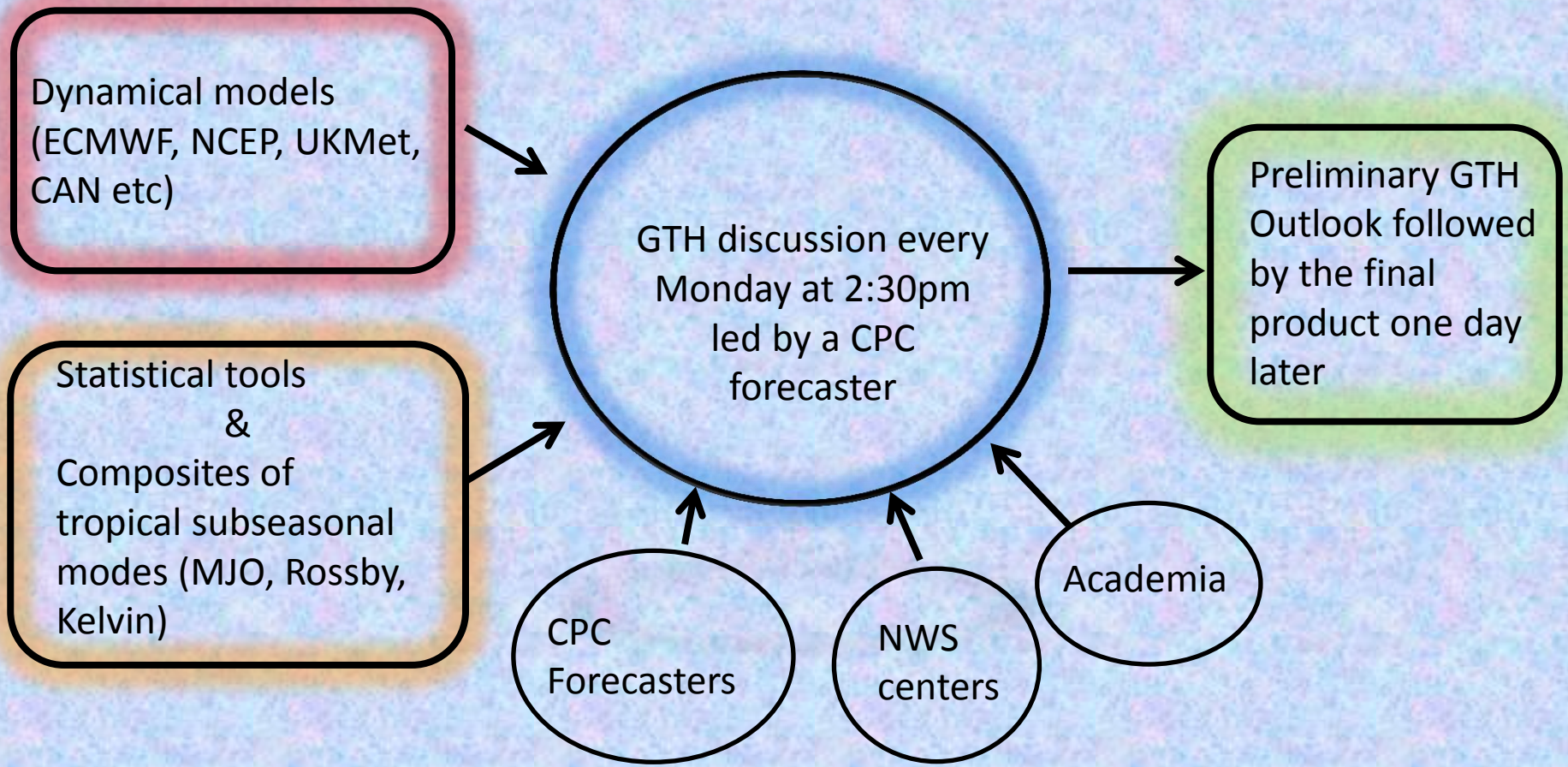
Day 0 - Day 7

Week 2 – Week 4
Month 1 – Month 2

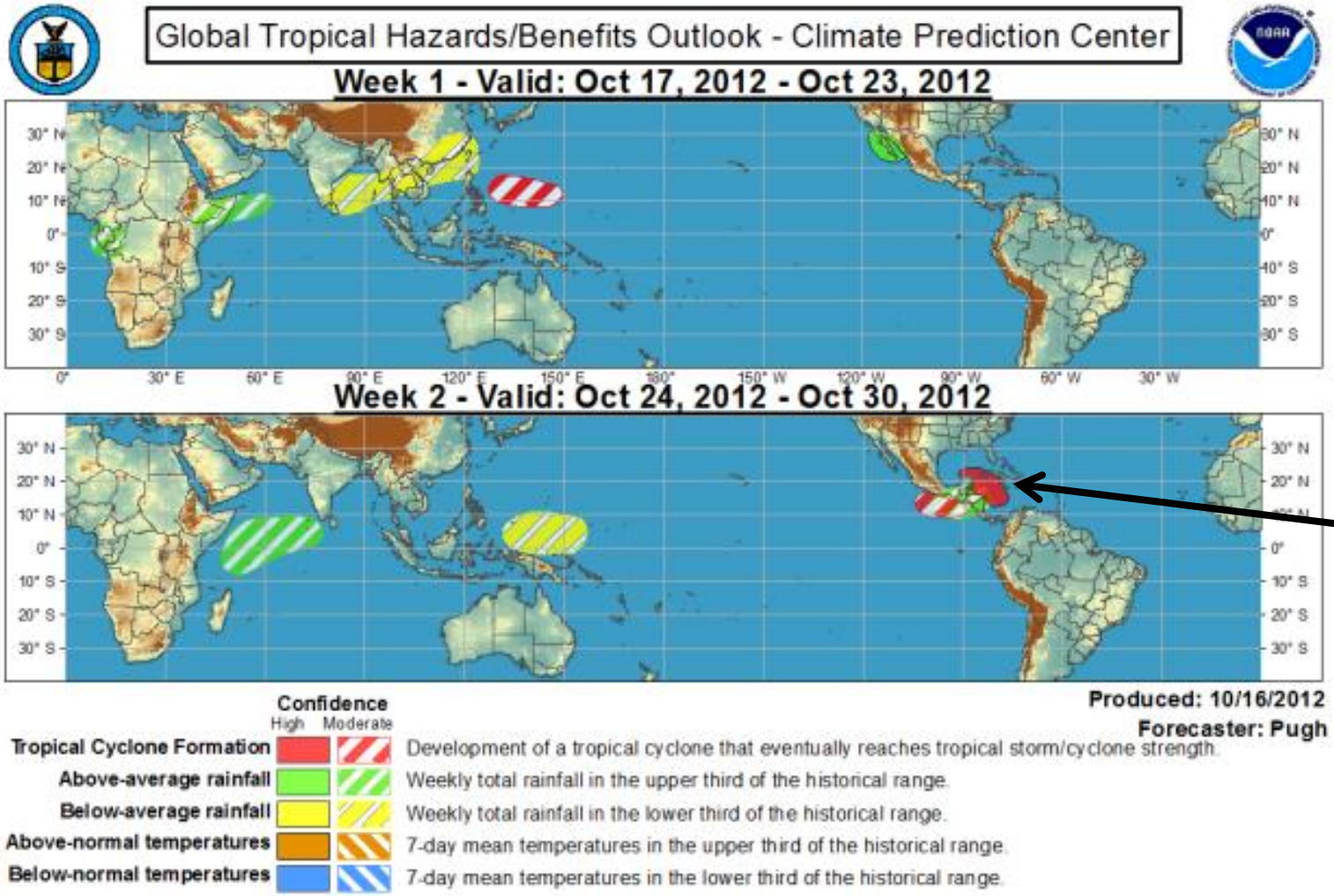
Season 1 – Year 1

The Global Tropical Hazards and Benefits Outlook (GTH)

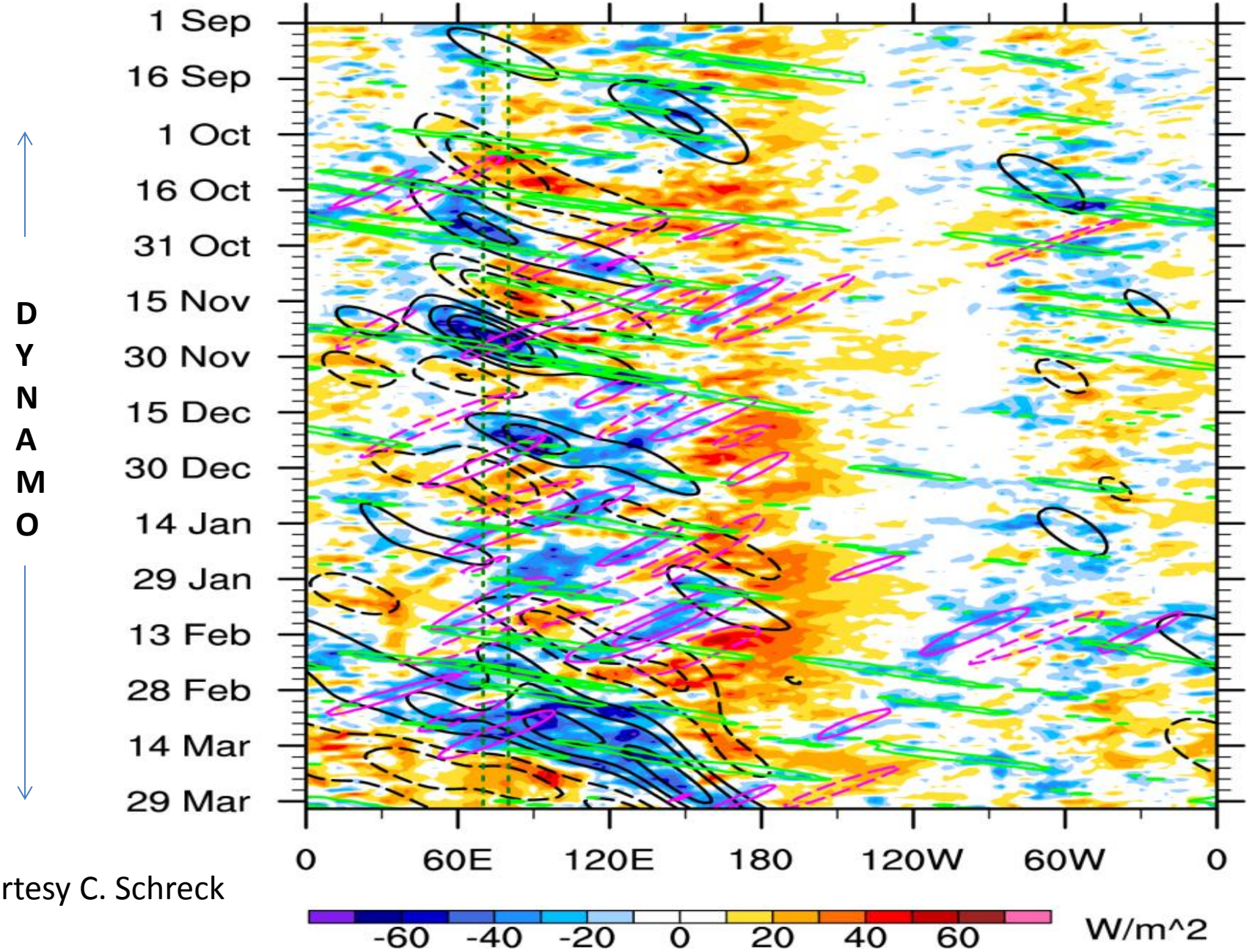
Developed at NOAAs Climate Prediction Center: <u>in operations since 2006</u>



Example of GTH Outlook issued October 16th: Tropical Cyclone Sandy



Scientific basis for GTH outlooks: Kelvin, Rossby and MJO modes



Courtesy C. Schreck

Some improvement paths for the GTH:

- Objective consolidation of models as a first guess forecast
- Consolidation based on a better understanding of the physics of tropical subseasonal variability
- Better understanding of the physics by exploring observational databases: DYNAMO
- Discussion with modelers on the strengths and weaknesses of the models
- Introducing new products in collaboration with stakeholders

CINDY/DYNAMO Field Campaign – 1/10/2011 to 31/3/2012


Falcon

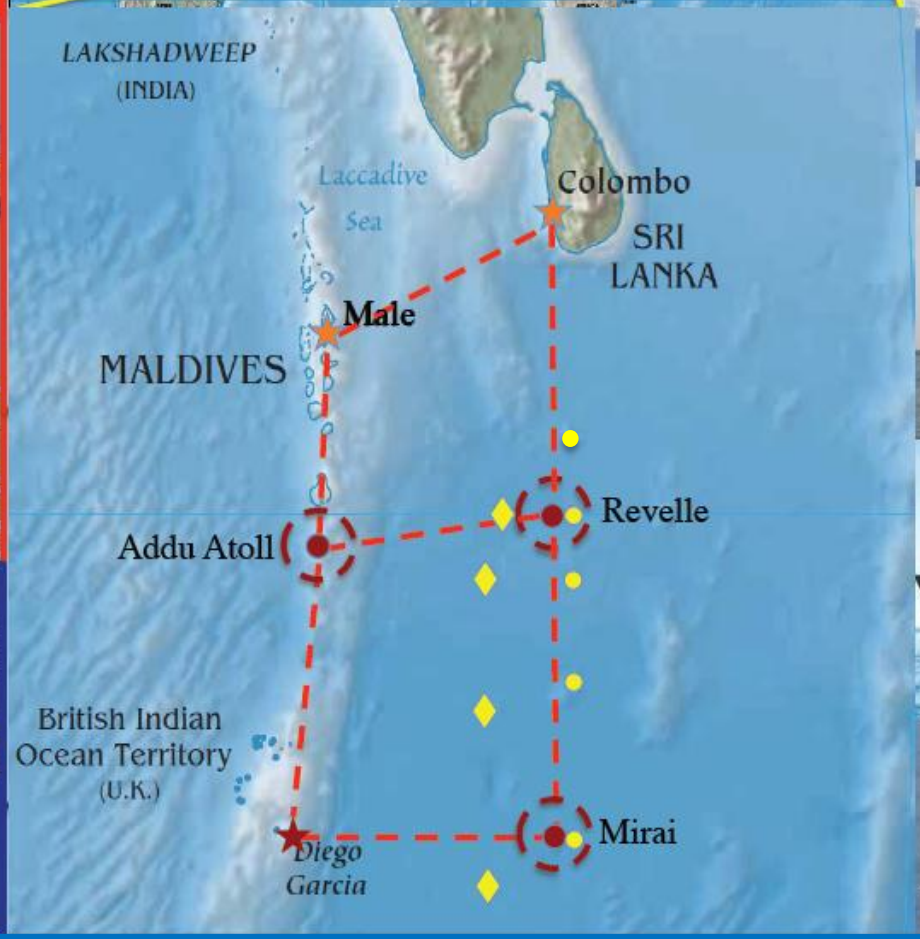

S-PolKa


SMART-R


AMF2


ISS


P-3




R/V B. Jaya-III


R/V R. Revelle


R/V S. Kanya


R/V Mirai

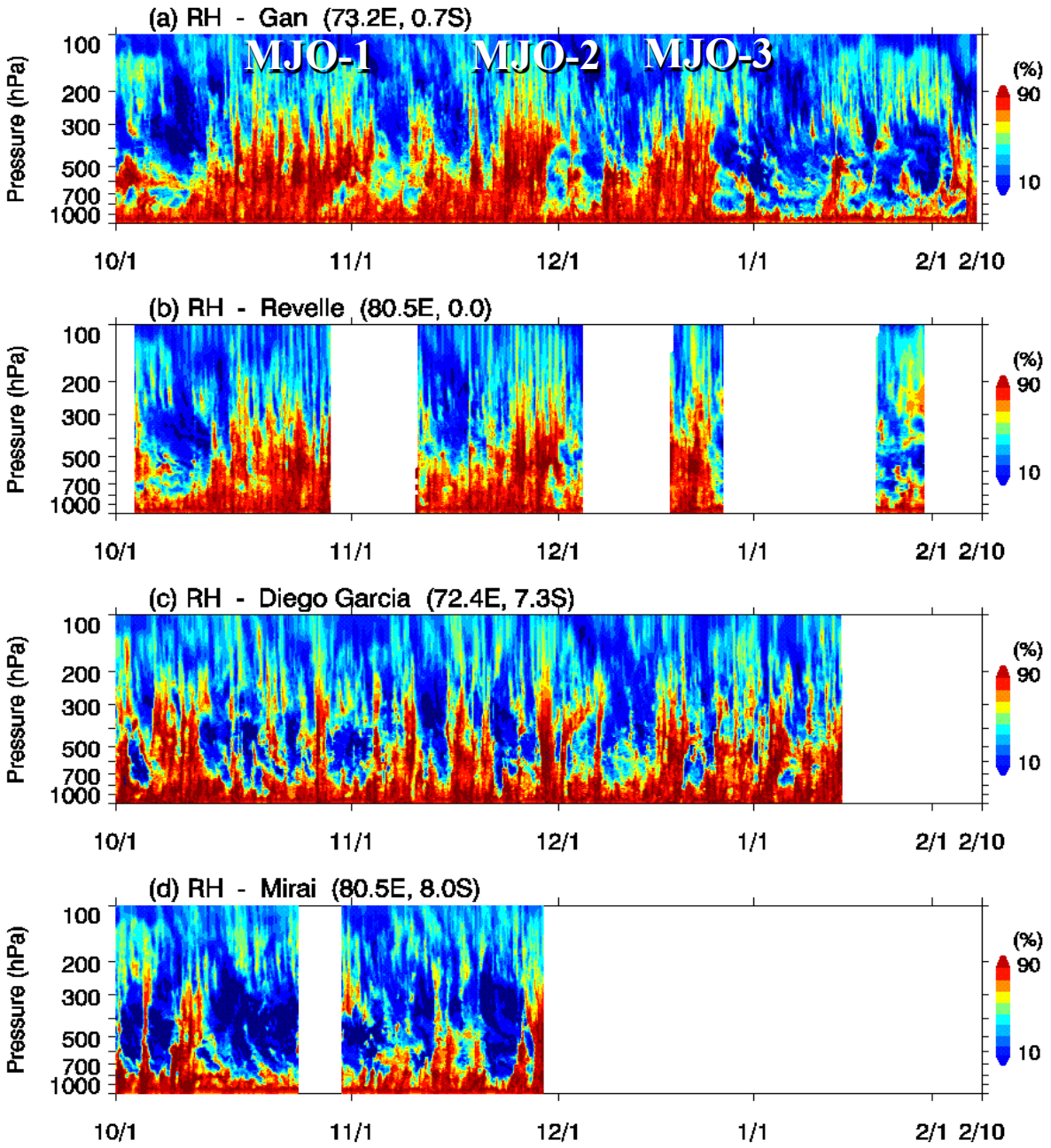
DYNAMO Radiosondes: Relative humidity

Gan

R/V Revelle

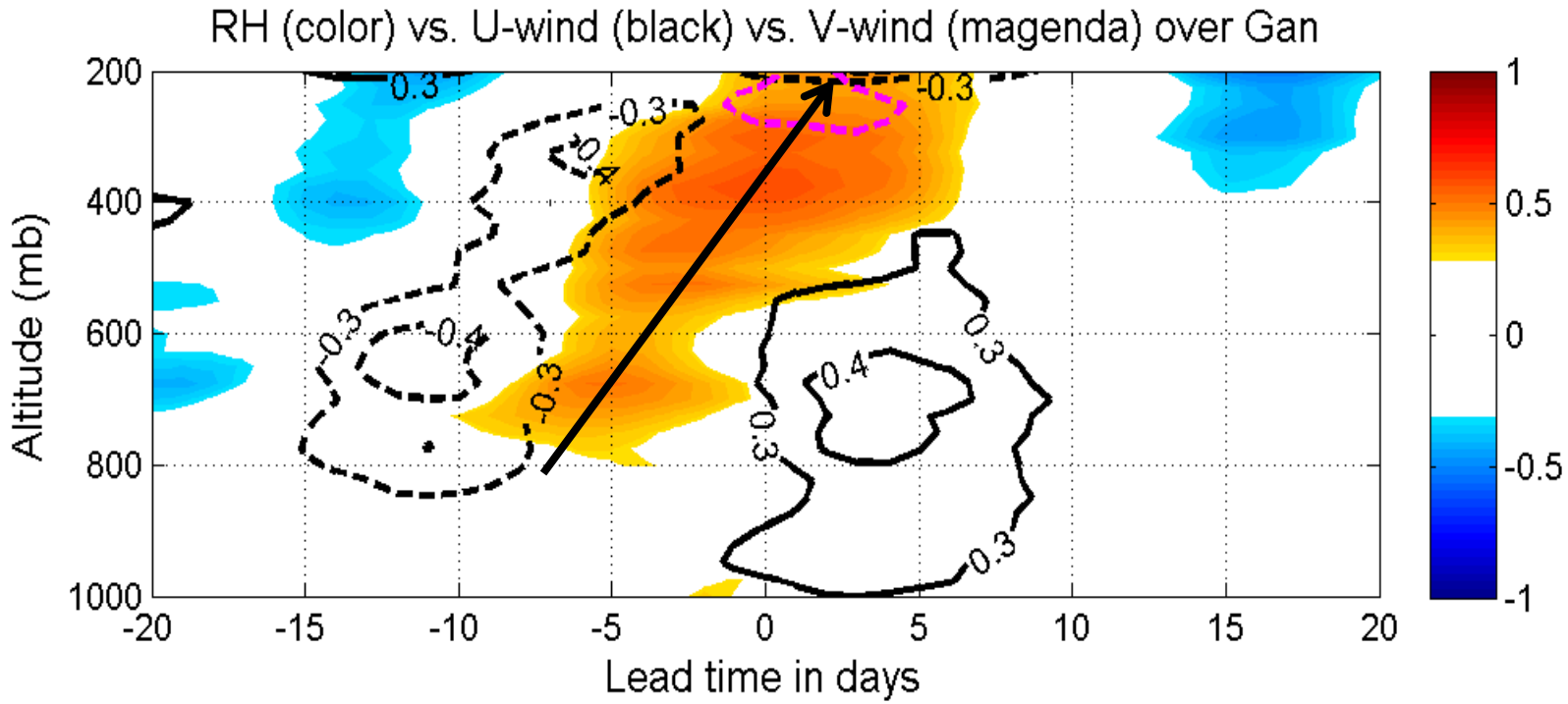
Diego Garcia

R/V Mirai



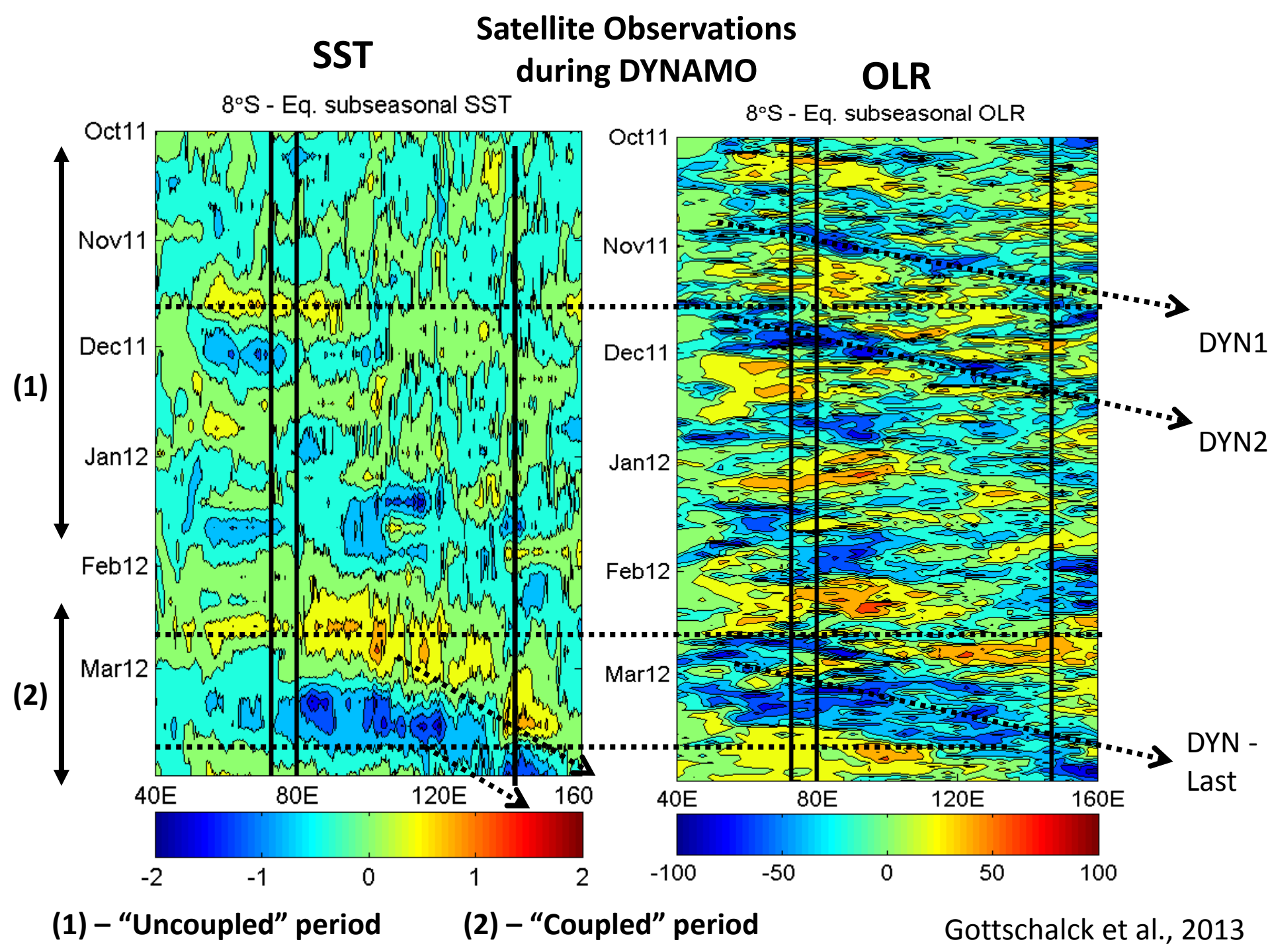
On the physics of the MJO

Lagged correlations: -RMM2 index (MJO entering Indian Ocean) vs. DYNAMO OBS. (RH and Wind) at Gan Island



Observations are indicative of a moisture recharge process as in Benedict and Randall (2007)

Satellite Observations during DYNAMO



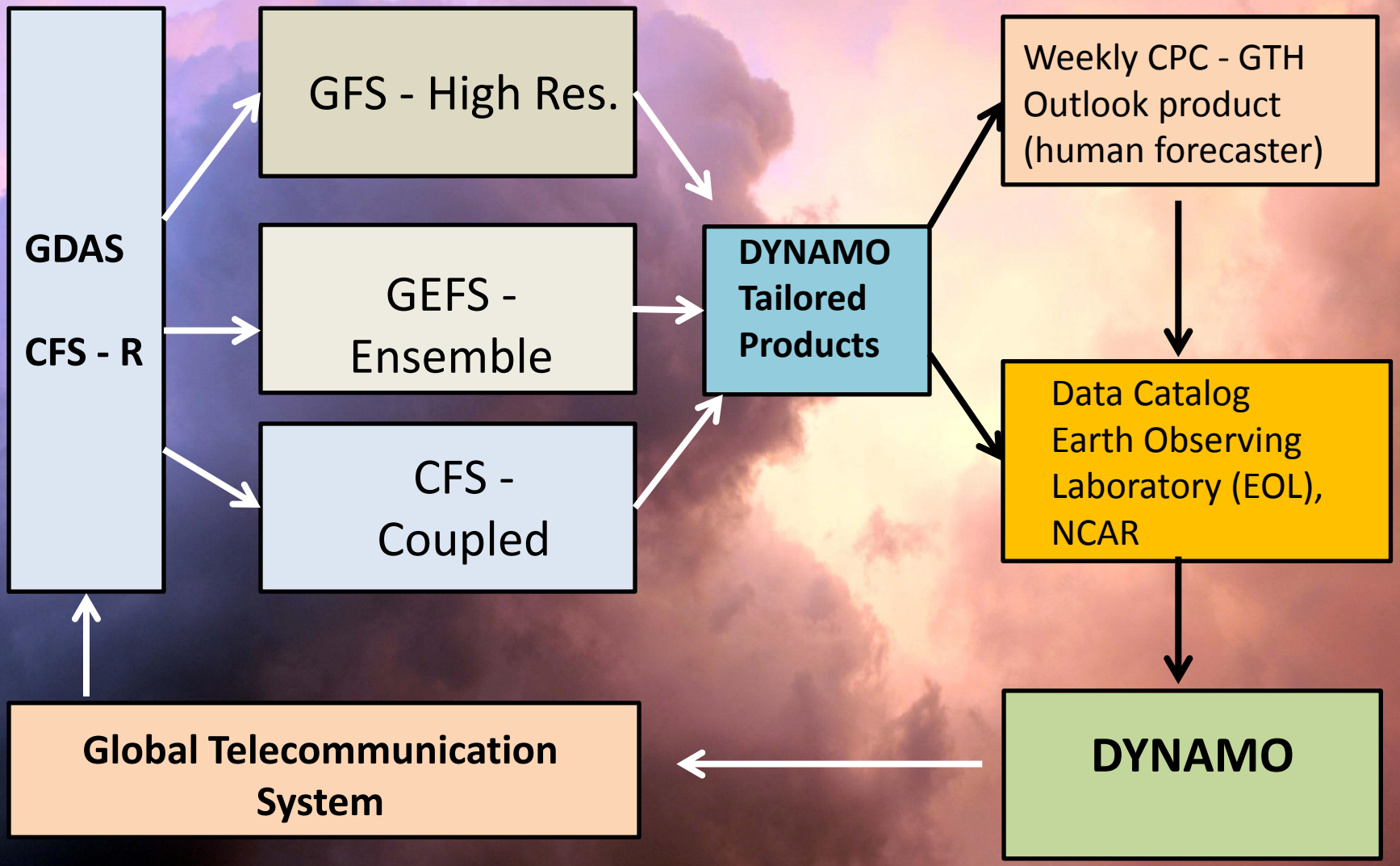
(1) – "Uncoupled" period

(2) – "Coupled" period

Gottschalck et al., 2013

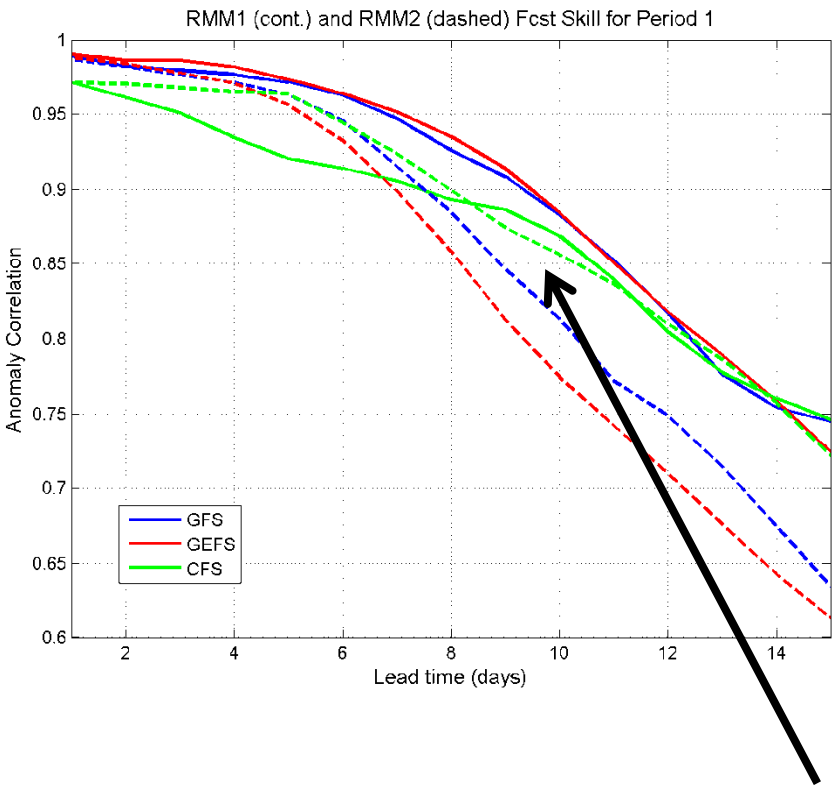
From NCEP to DYNAMO to NCEP

CPO funded CPC and ESSIC to provide monitoring and forecast support to DYNAMO

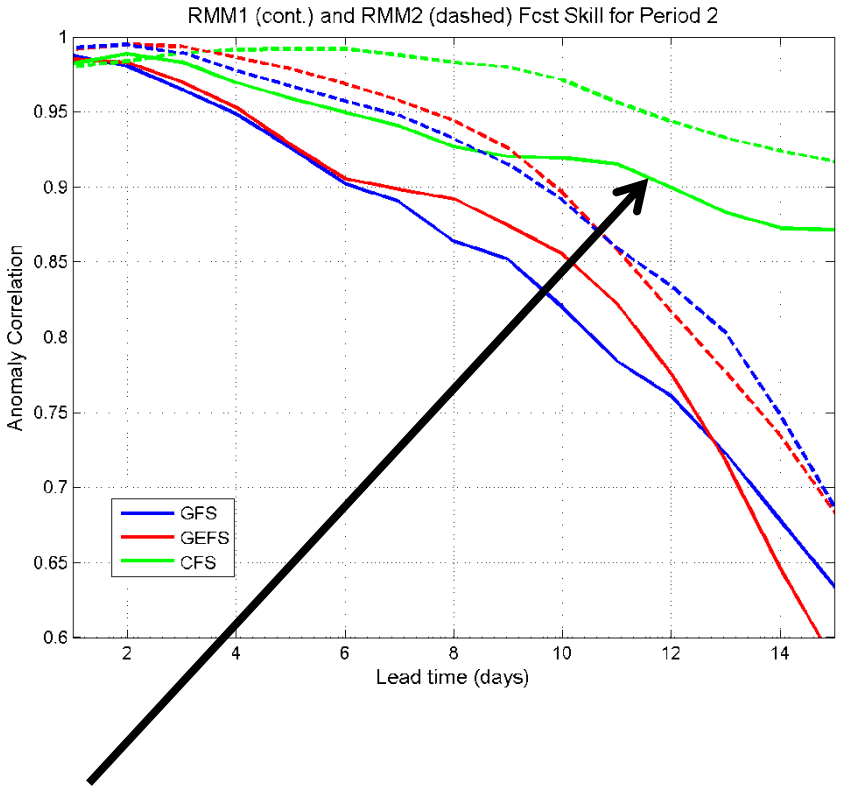


Summary of MJO forecast skill for the GFS (blue), GEFS (red), CFS (green) during DYNAMO for RMM1 (continuous) and RMM2 (dashed)

DYNAMO Sub-period 1 ("Uncoupled")



DYNAMO Sub-period 2 ("Coupled")



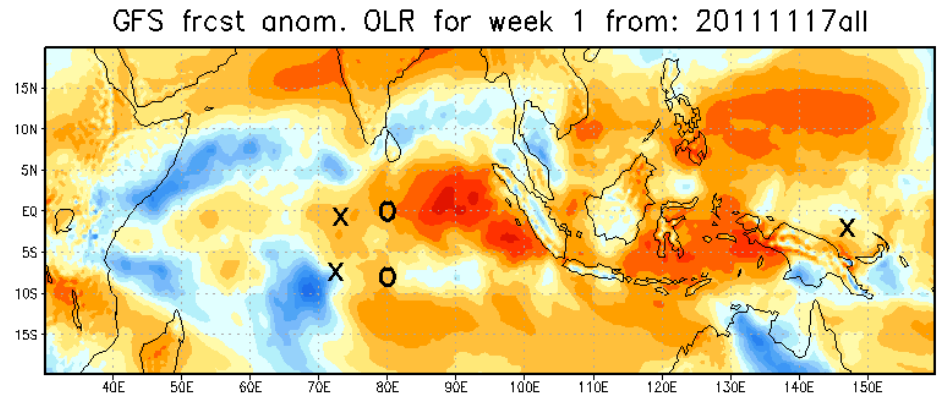
There is a very important increase in forecast skill when using the coupled ocean – atmosphere model (CFS) between the two DYNAMO periods.

Investigating the first sub-period of DYNAMO
("Uncoupled" period: all NCEP models similar skill)

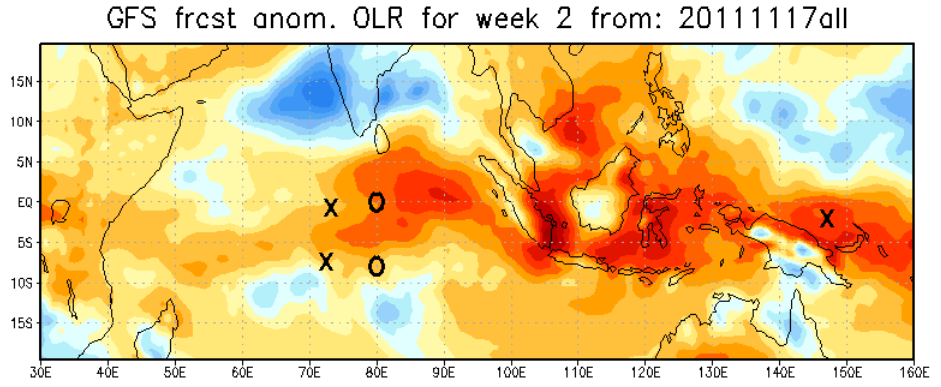
Forecast of Anomalous OLR (GFS) for the second DYNAMO MJO event

Forecast

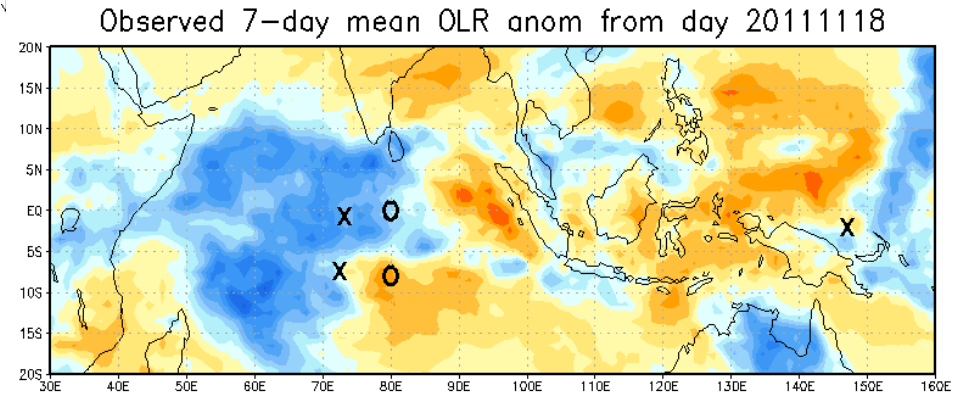
Week 1

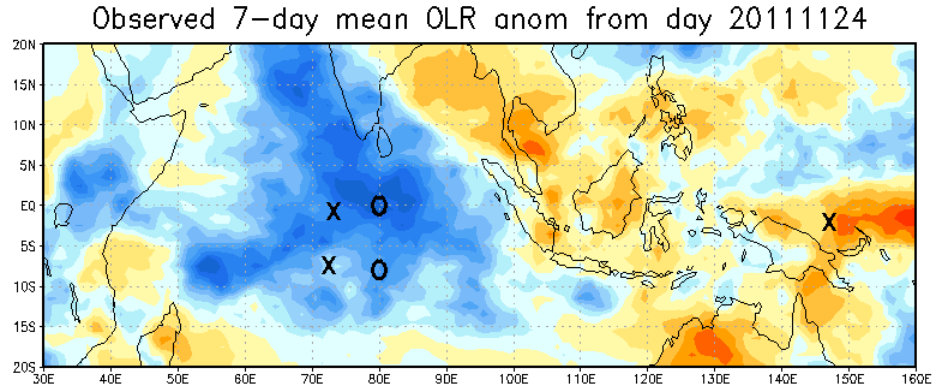


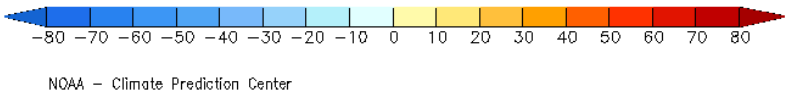
Week 2

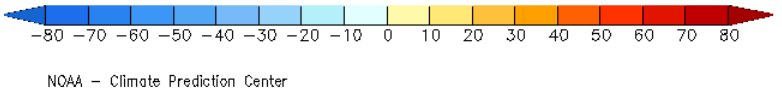


Verification

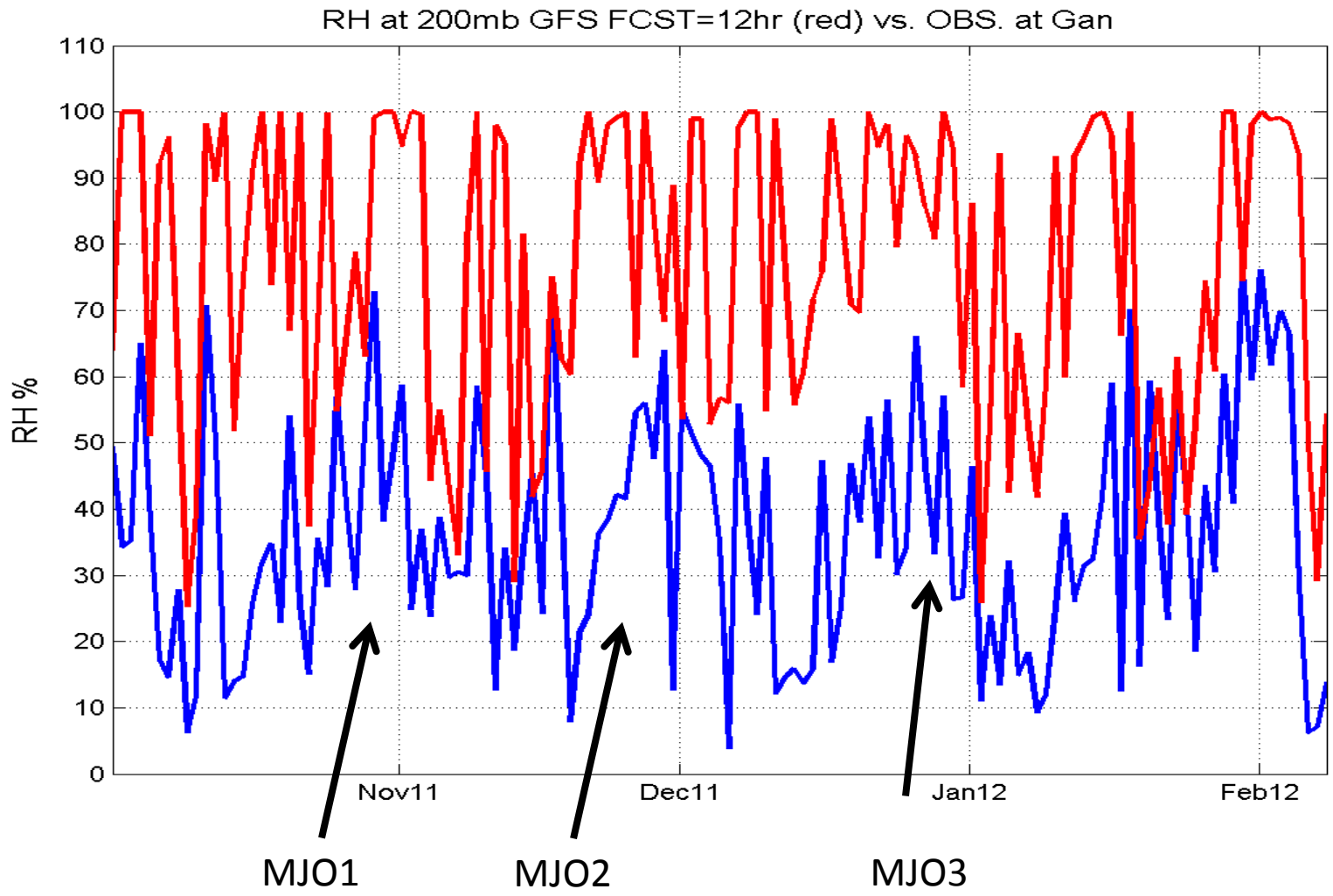




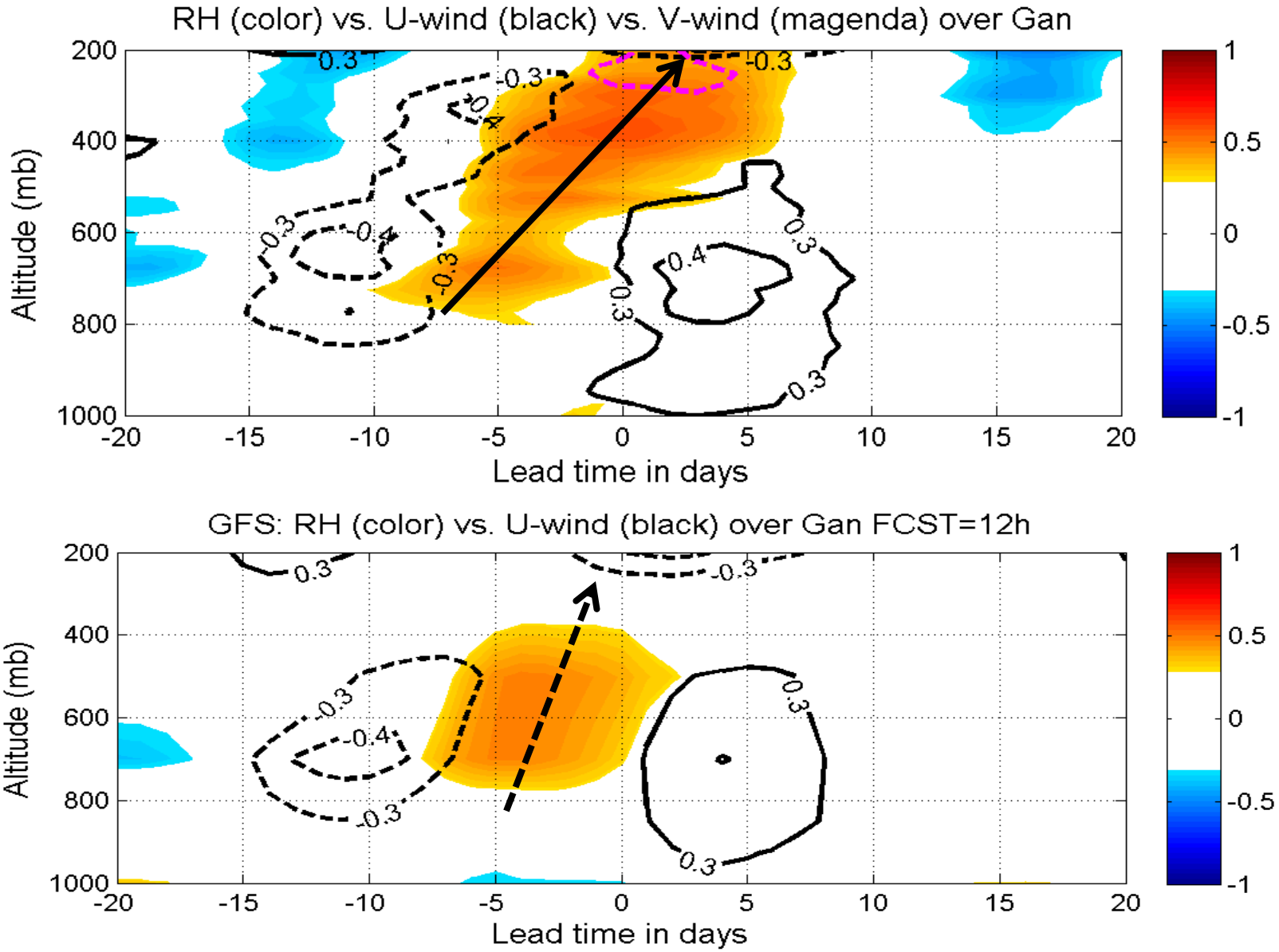




200 hPa Relative Humidity at Gan: DYNAMO (blue) and GFS at fcst=12h (red)

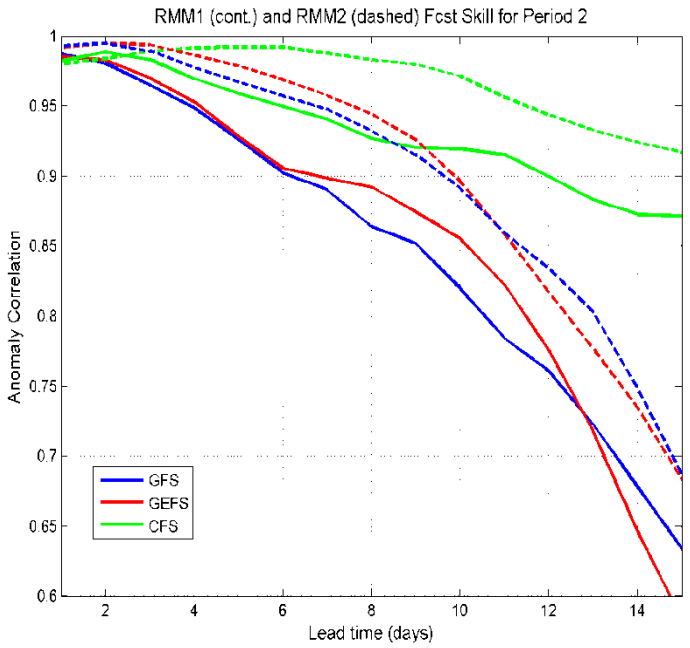


Lagged correlations: -RMM2 index (MJO over Indian Ocean) vs. OBS and FCST fields (12h)



Investigating the second sub-period of DYNAMO ("Coupled" period: CFS model is better)

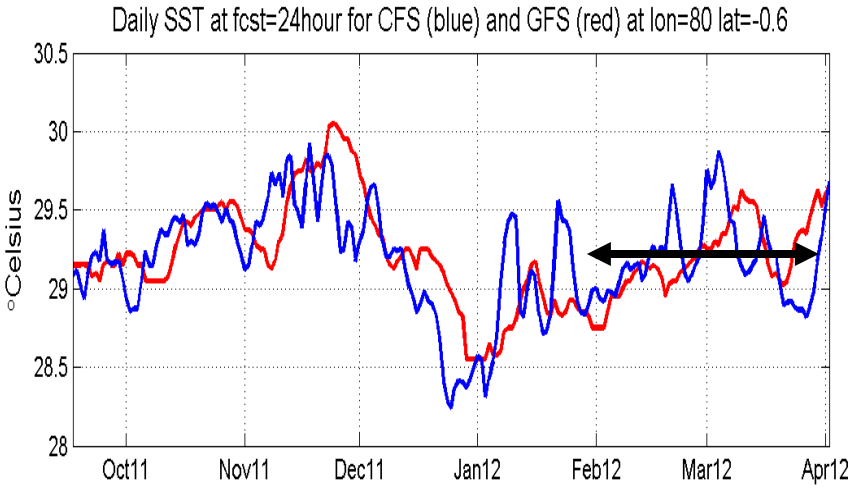
RMM-index skill comparison for period 2 of DYNAMO

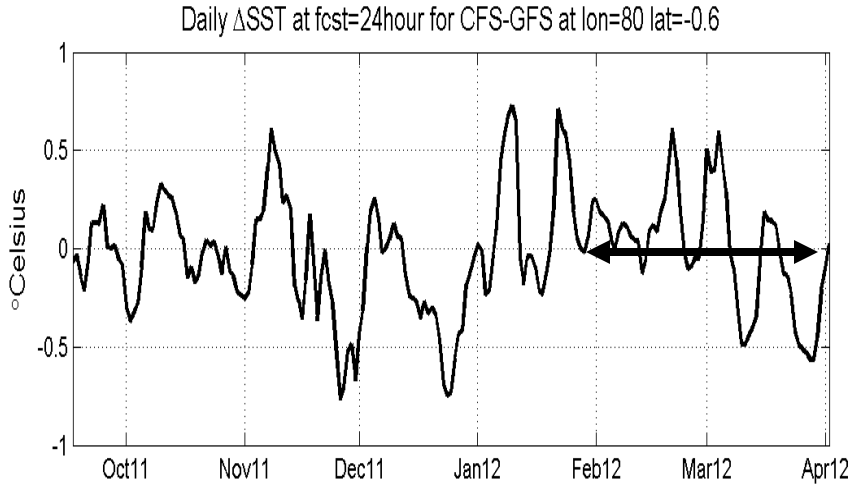


Can we test the hypothesis that the increase in skill of the CFS is due to 'coupling' ?

Investigate the SST forcing for GFC and CFS at fcst time=24h

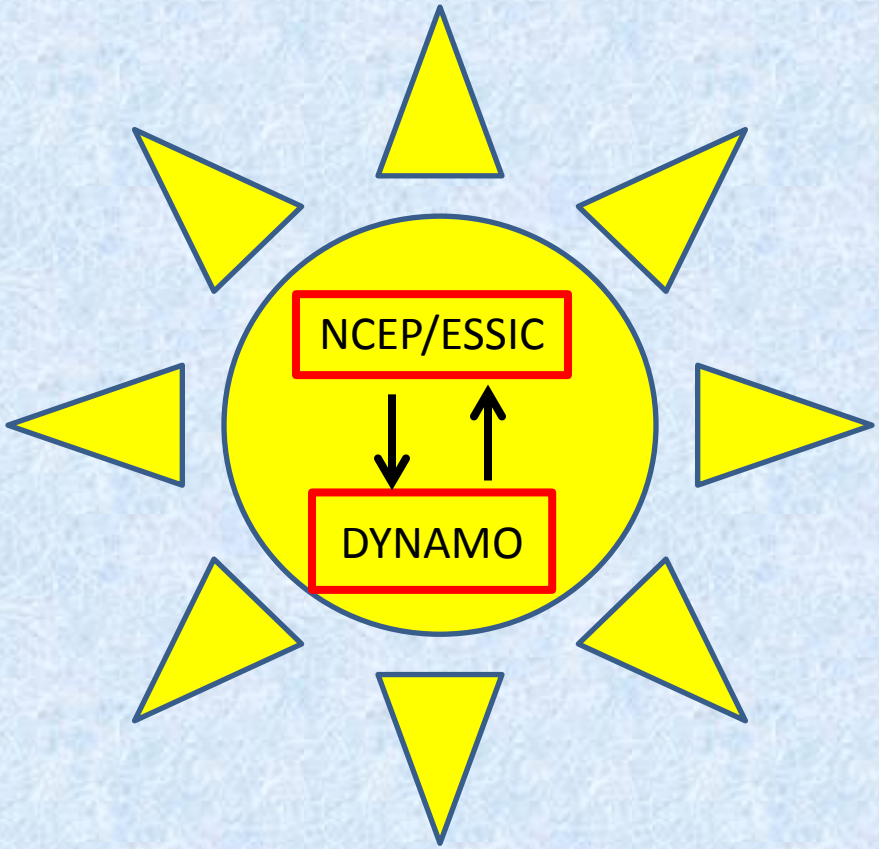
SST and ΔSST for CFS and GFS at Revelle at forecast time 24 hours





Subseasonal variability is less important in GFS forcing than in CFS; can we provide a better forcing to GFS?

Summary:



Define objective methods to combine dynamical model forecast based on the physical sources of subseasonal predictability i.e., Kelvin, Rossby and MJO modes

Investigate the relative humidity bias in the upper troposphere of the GFS

Investigate SST forcing as a reason for occasional divergences in forecast skill in the GFS family of models

The collaboration between ESSIC-NCEP-DYNAMO funded by NOAA/CPO…

… delineated a number of priorities for the improvement of the GTH Outlook which…

… is leading to propose future work for increasing the skill of the GTH

CONCLUSIONS

- ***Hypothesis 1*:** Sometime ocean – atmosphere interactions appear to be important for subseasonal variability suggesting that coupled forecast models should be more skillful overall.

- Such an event occurred towards the end of DYNAMO. Indeed, this event was better predicted by the coupled CFSv2 model than the uncoupled GFS. However the forcing SST field of the GFS contains less subseasonal variations than the CFS model even at forecast time 24 hours. At this time it is difficult to directly attribute the better CFS skill to coupled ocean – atmosphere interactions during the second weeks of the forecast. Experiments are being proposed to investigate this issue.

- ***Hypothesis 2*:** The GFS cannot propagate eastward a coherent large scale OLR signal during DYNAMO due to the relative humidity bias in the upper troposphere. Experiments are being proposed to investigate this issue.

- ***Hypothesis 3*:** Improvements in ocean mixed layer physics will improve the SST forecast for week > 2. Experiments are being designed and will be proposed.


Questions?

Improving the GTH using better observations of tropical subseasonal variability:

DYNAMO

CINDY/DYNAMO Field Campaign – 1/10/2011 to 31/3/2012


Falcon

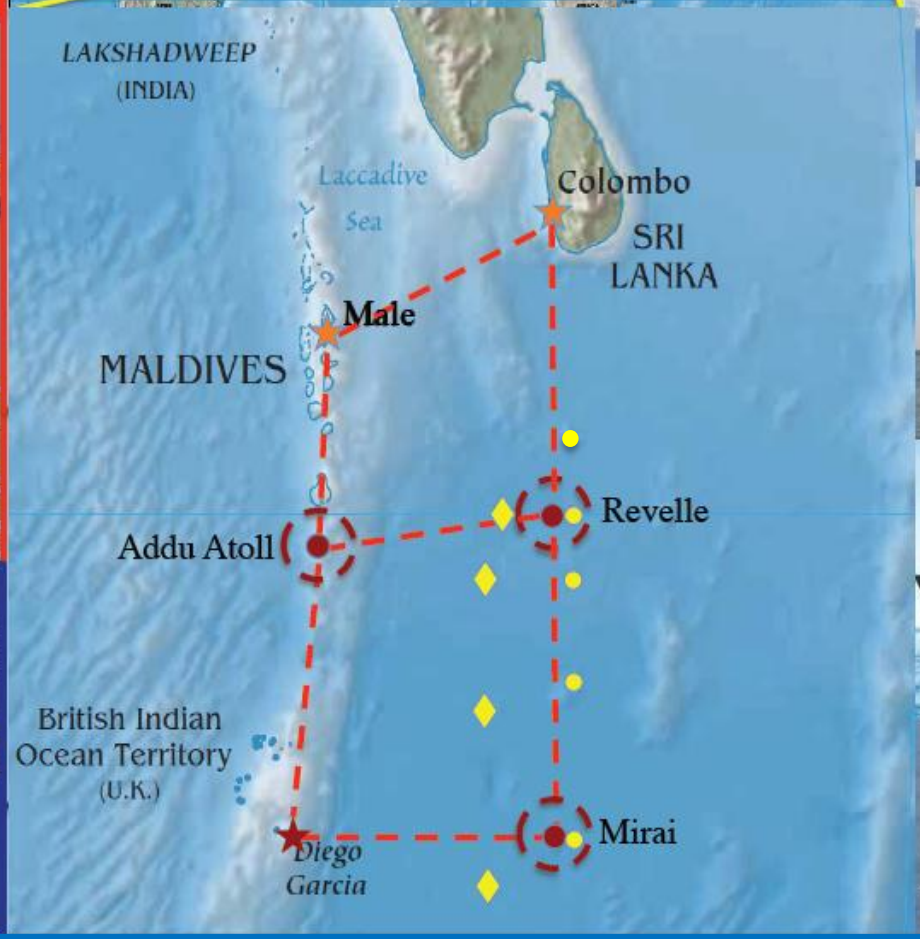

S-PolKa


SMART-R


AMF2


ISS


P-3




R/V B. Jaya-III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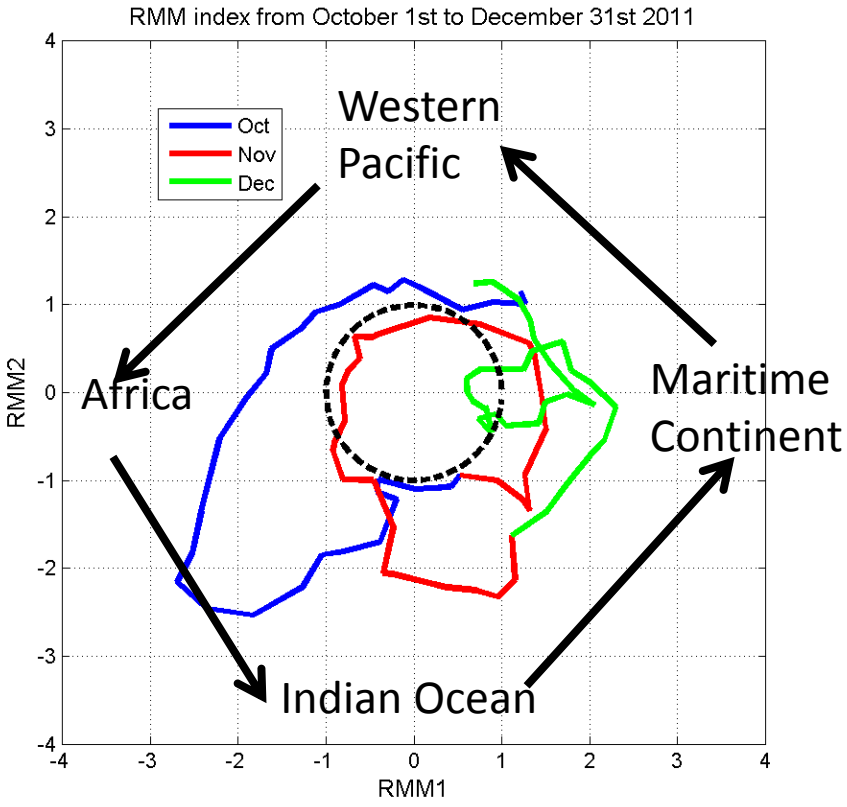
R/V Mirai

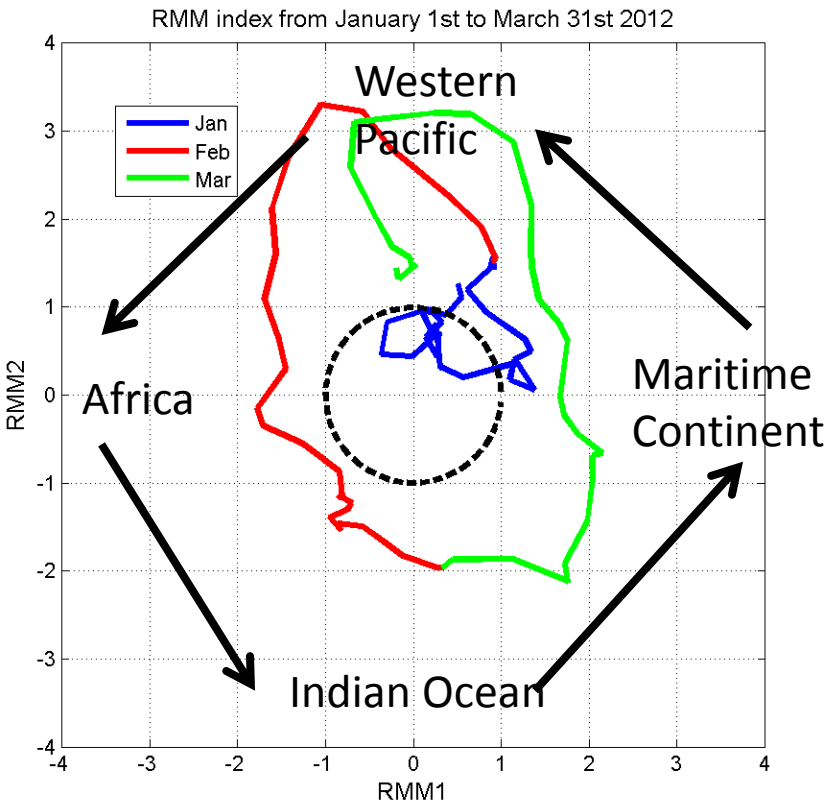
DYNAMO was a lucky campaign!

Review of DYNAMO through the RMM index

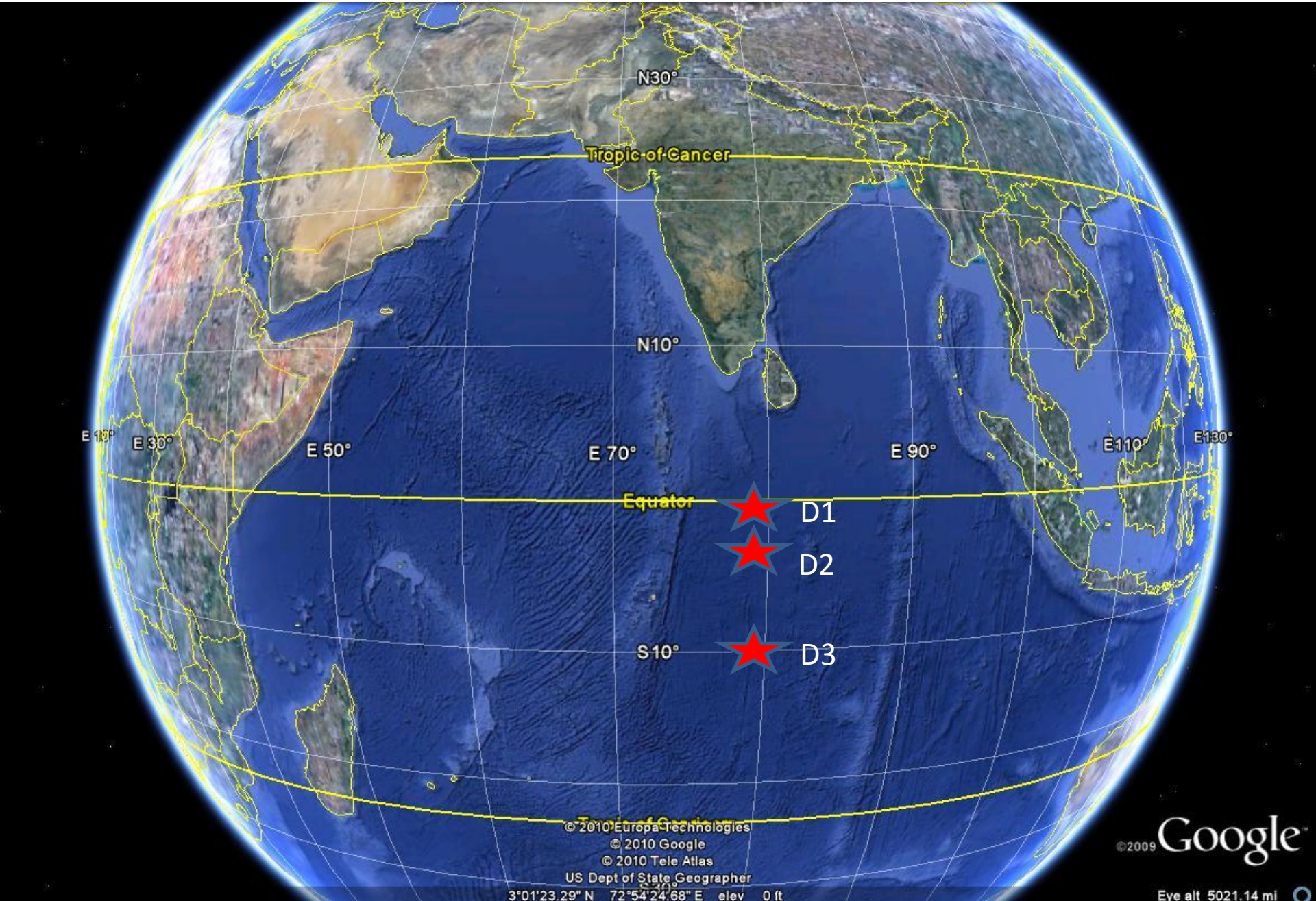
October to December 2011



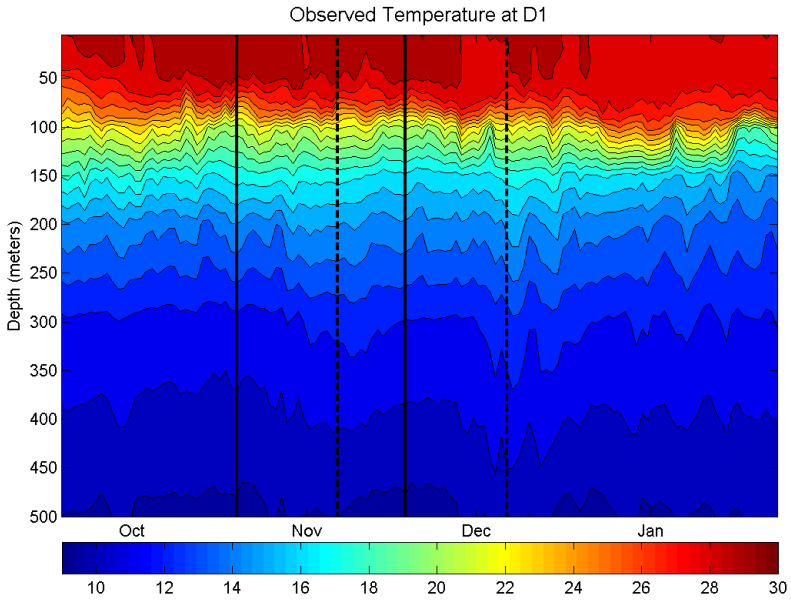
January to March 2012

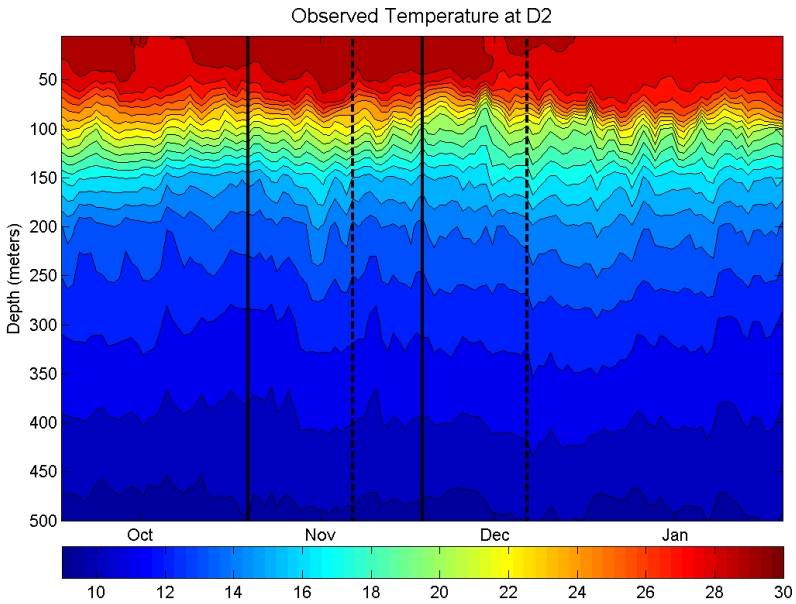


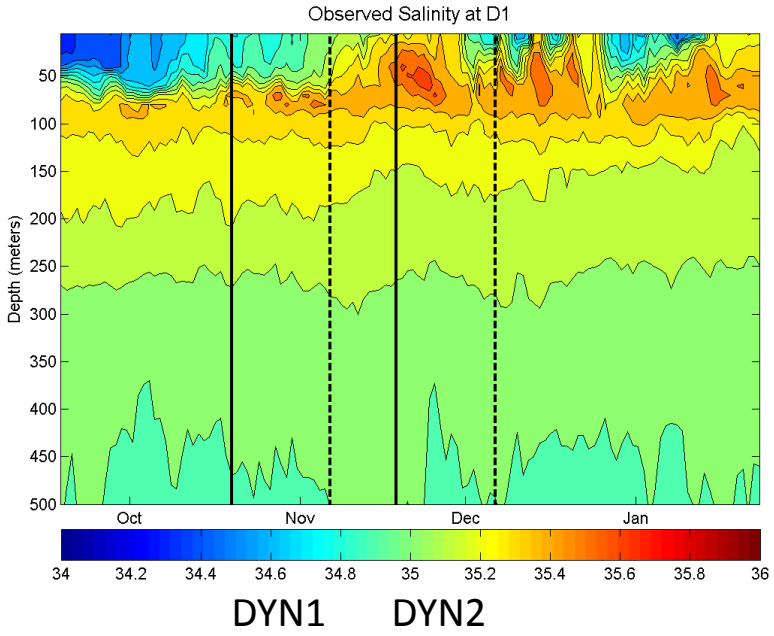
DYNAMO moorings: From September 18th, 2011 to January 23rd, 2012

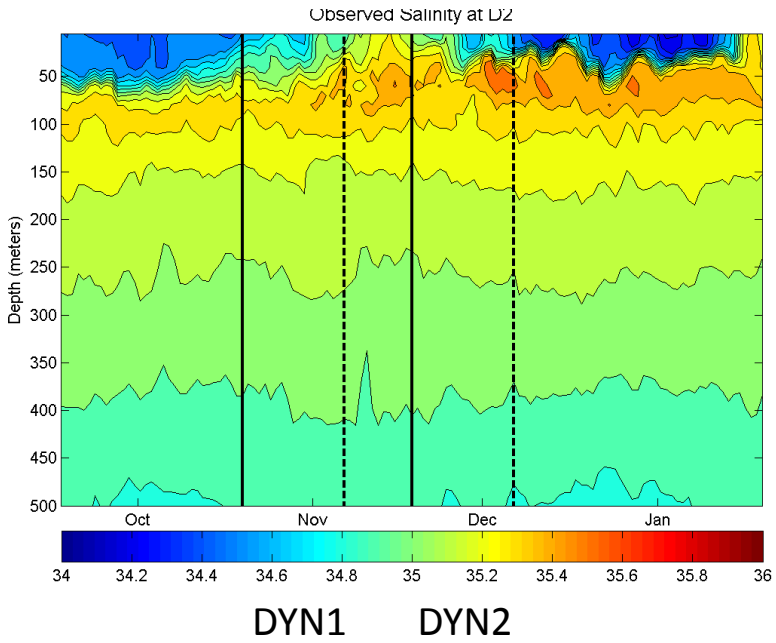


Synopsis of DYNAMO moorings D1 and D2 (courtesy Ren-Chieh Lien)





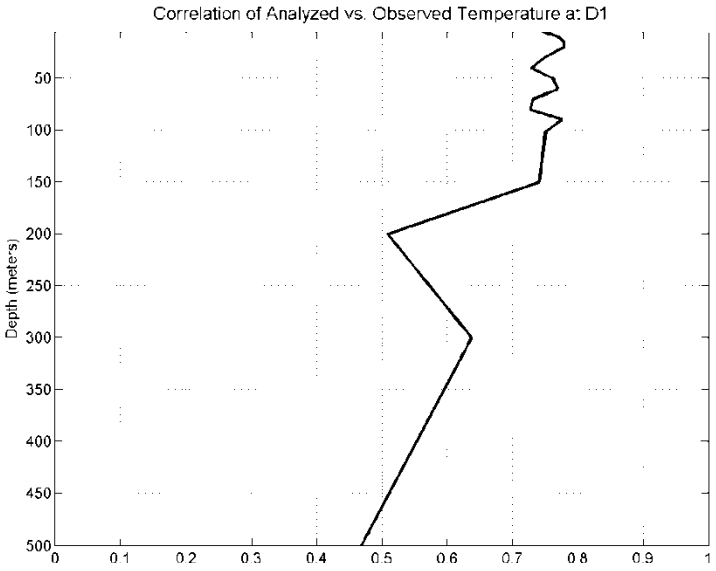




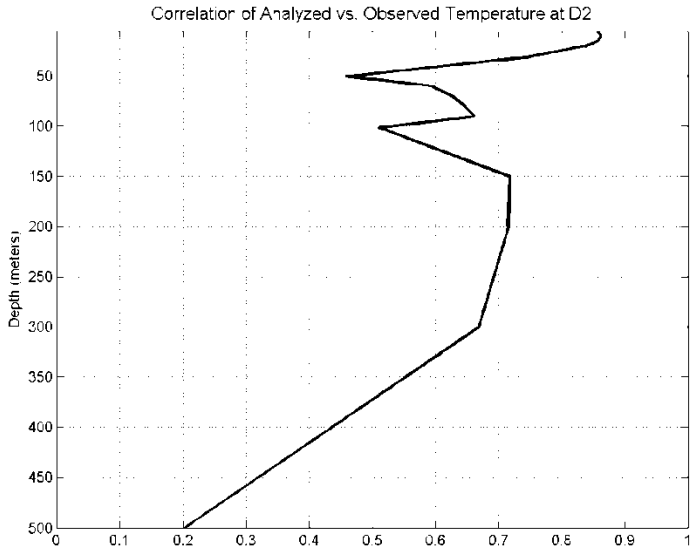
Correlation between observed and CFS forecast Temperature fields

DYNAMO subsurface data were not sent to the GTS

Mooring D1



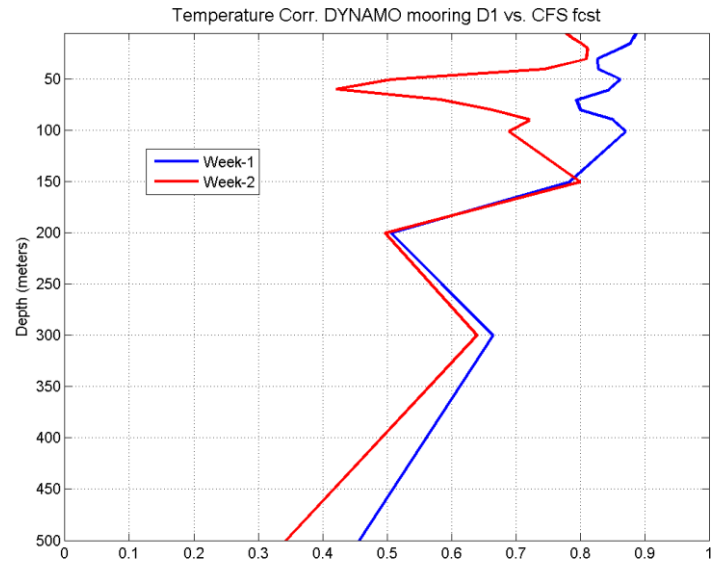
Mooring D2

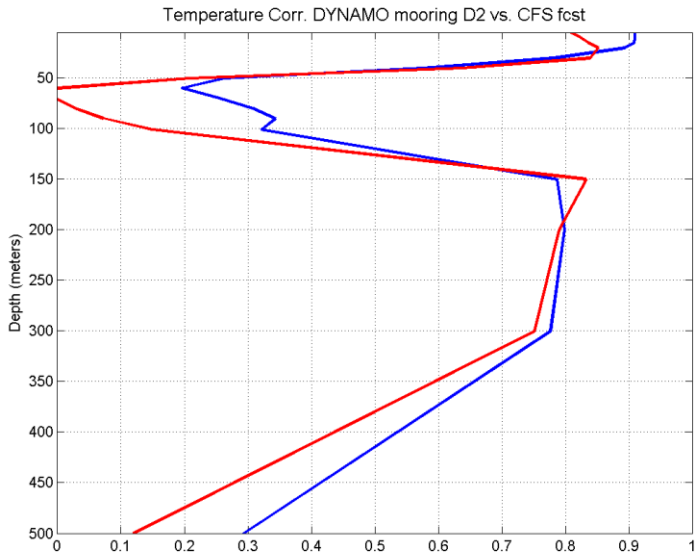


Initialization

CFS-Reanalysis vs. DYNAMO Daily data

D e p t h



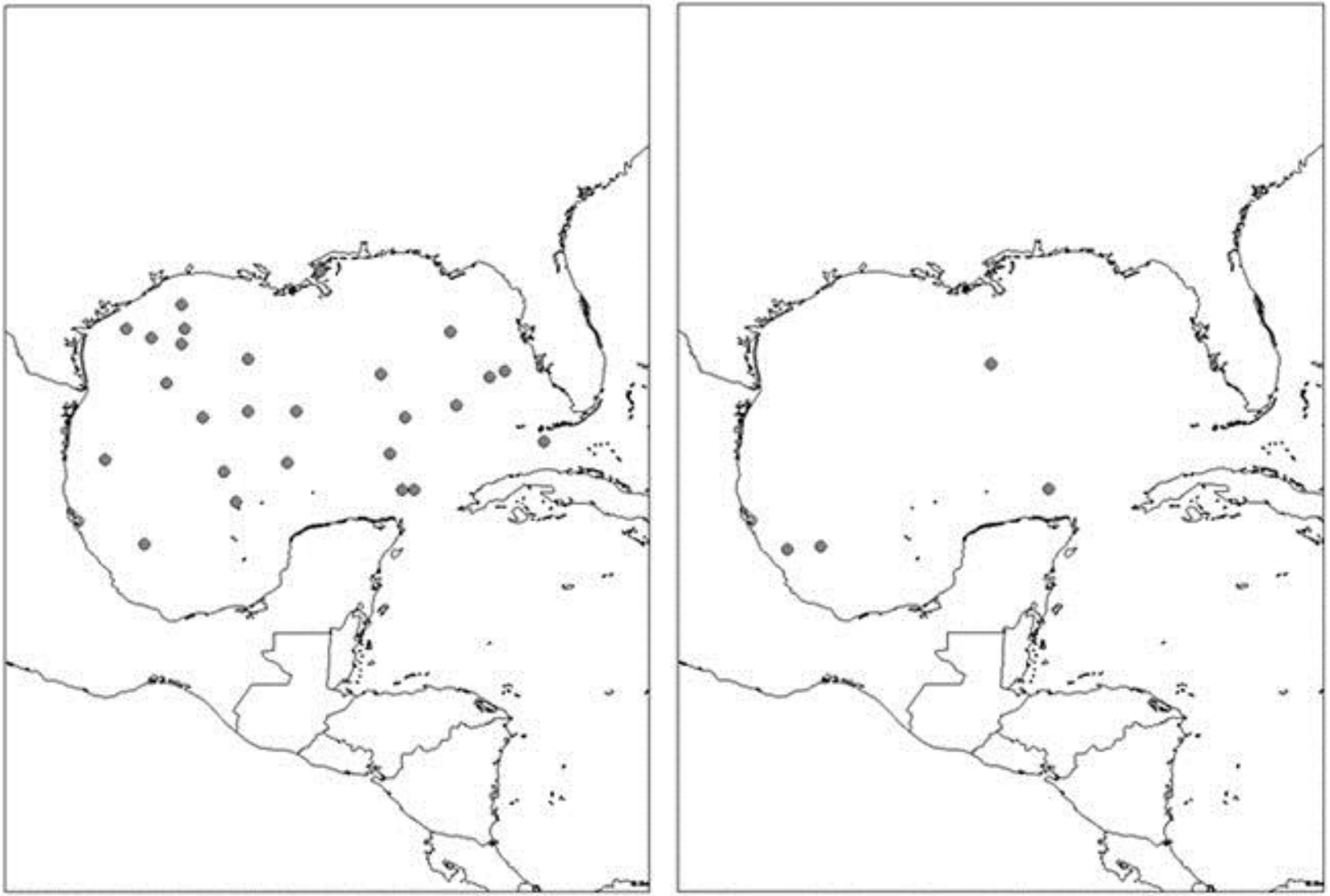


Forecast

CFS-Forecast vs. DYNAMO Weekly data

D e p t h

Very important drop in skill at the depth of the mixed layer – may affect forecast for > week 2

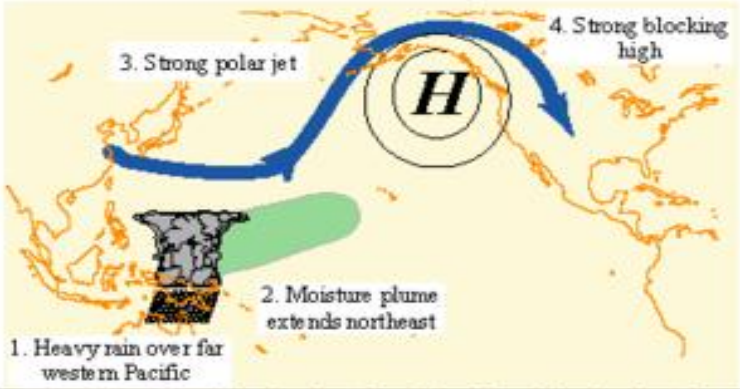


Genesis locations for storms forming in (left) MJO phases 1–2 and (right) MJO phases 6–7 over the period from 1974 to 2007

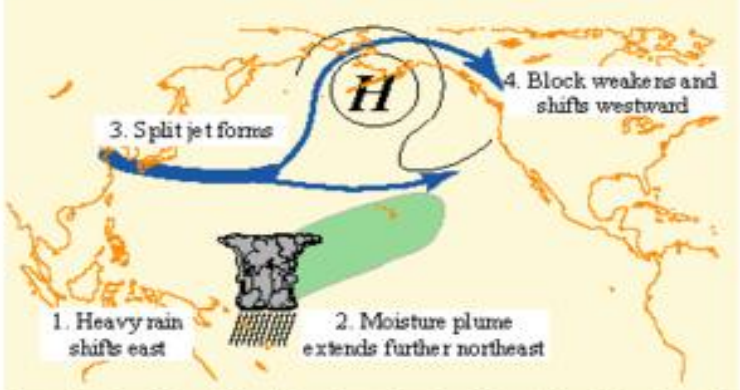
Klotzbach, 2010

Typical Wintertime Weather Anomalies Preceeding Heavy West Coast Precipitation Events

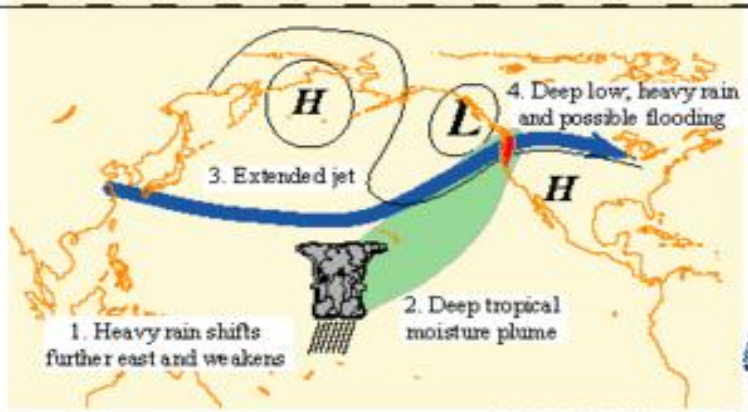
7-10 Days Before Event



3-5 Days Before Event



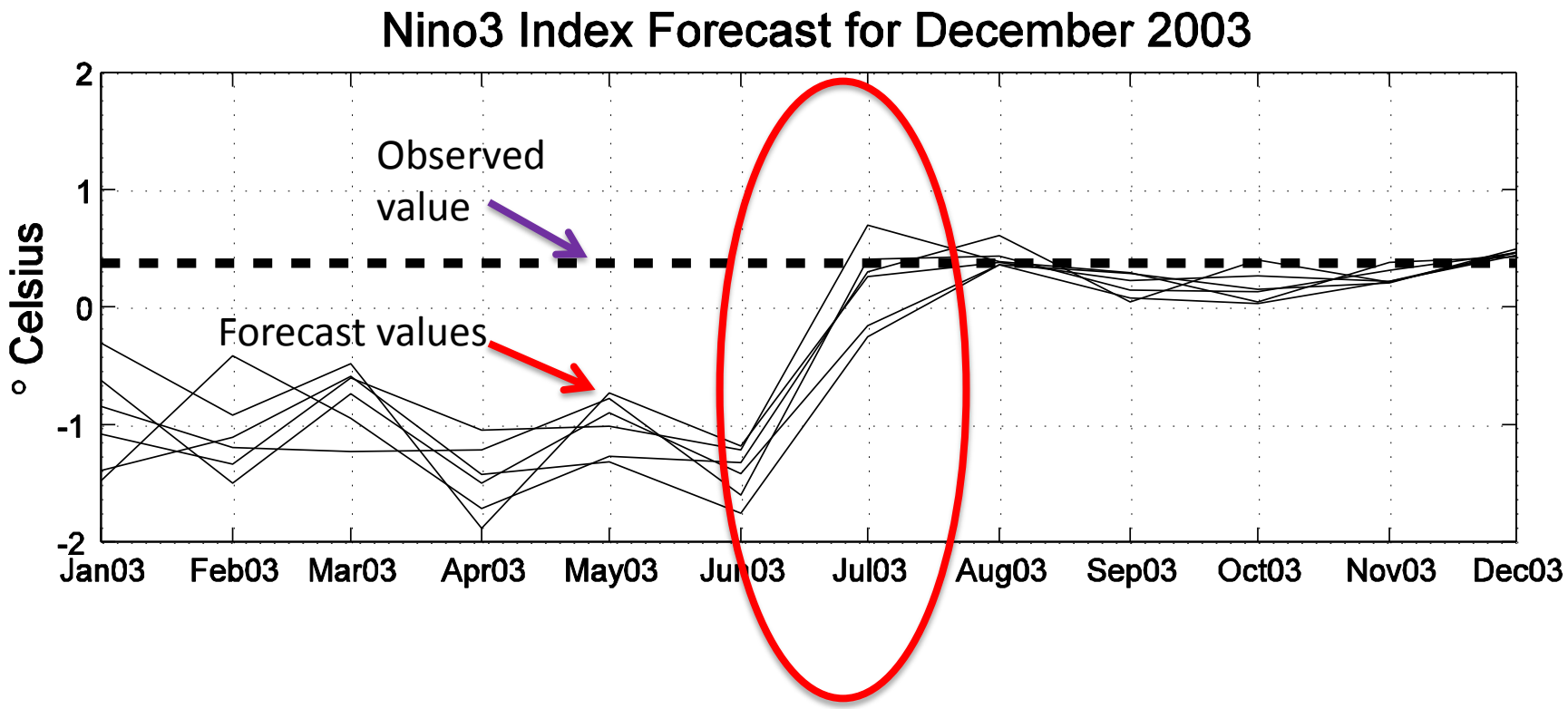
Precipitation Event



Climate Prediction Center/NCEP/NWS

Why subseasonal is important for interannual and beyond time scales….

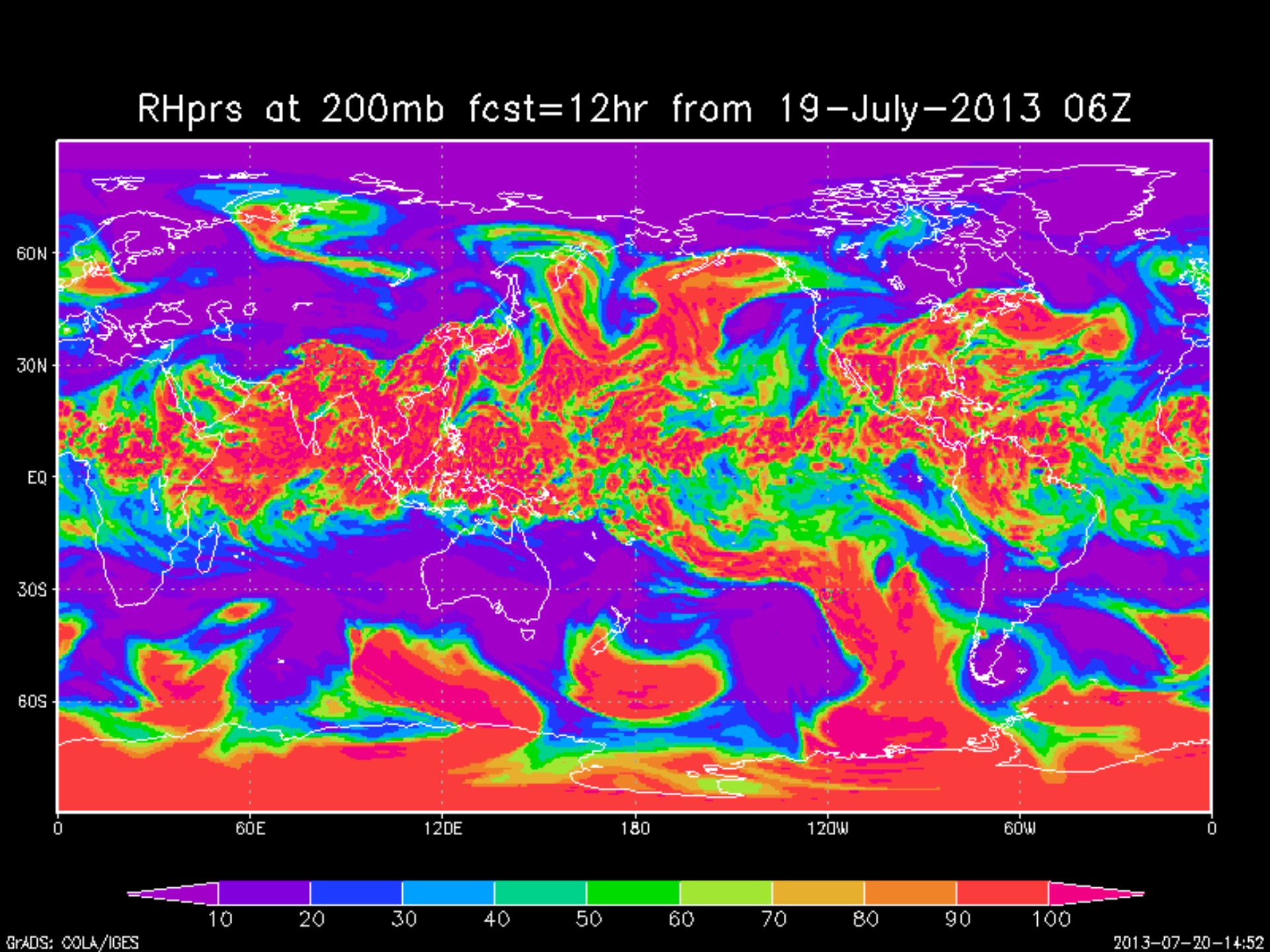
Forecasting ENSO with the NASA model

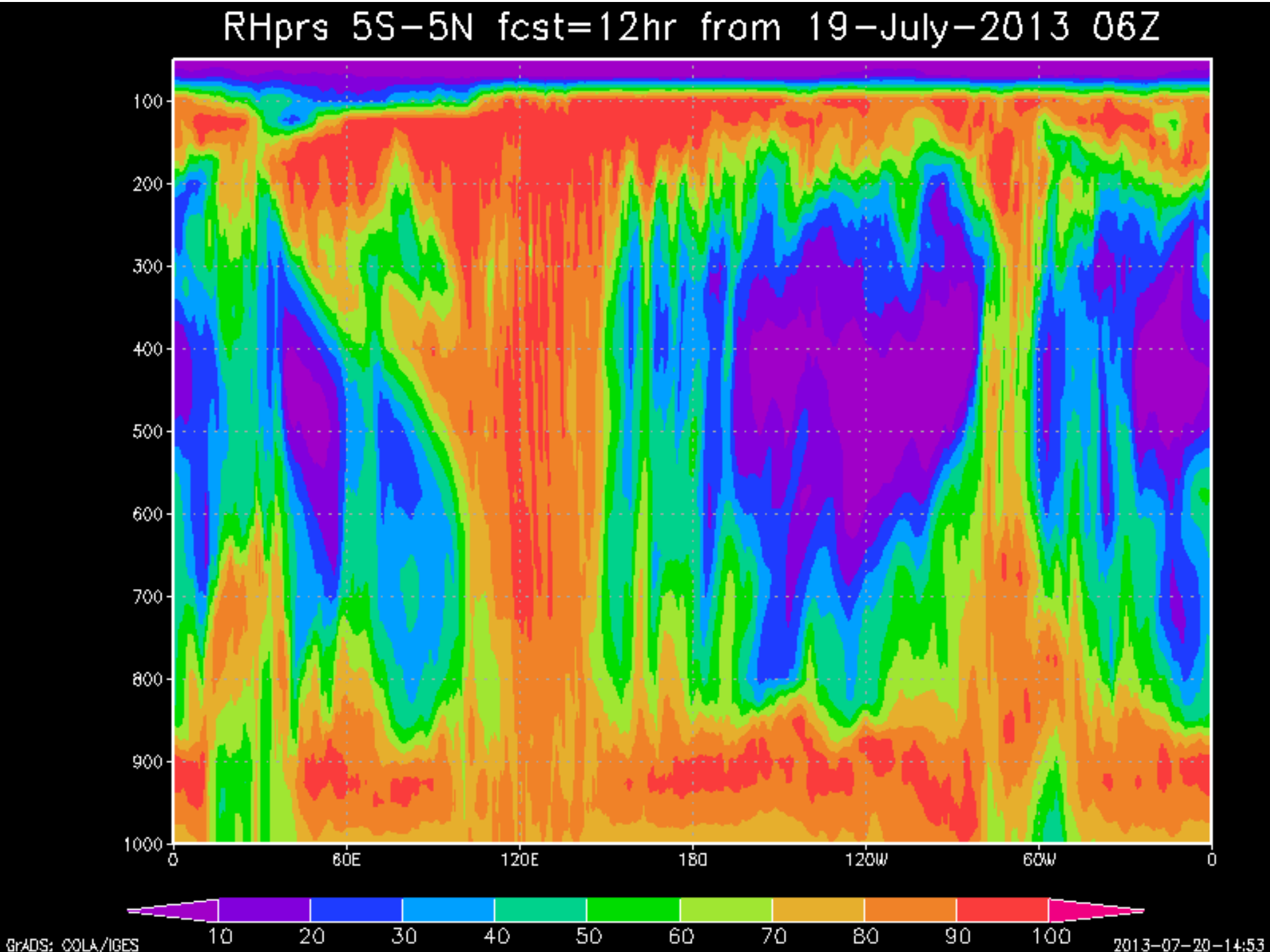


Observed intraseasonal activity modified the forecast from La Nina to neutral in just one month

(Vintzileos et al., 2005)

Sea Surface Temperature–Precipitation Relationship in Different Reanalyses (Kumar et al., 2013)


RHprs at 200mb fcst=12hr from 19-July-2013 06Z
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
10
20
30
40
50
60
70
80
90
100
GrADS: COLA/IGES
2013-07-20-14:52


RHprs 5S-5N fcst=12hr from 19-July-2013 06Z
100
200
300
400
500
600
700
800
900
1000
0
60E
120E
180
120W
60W
0
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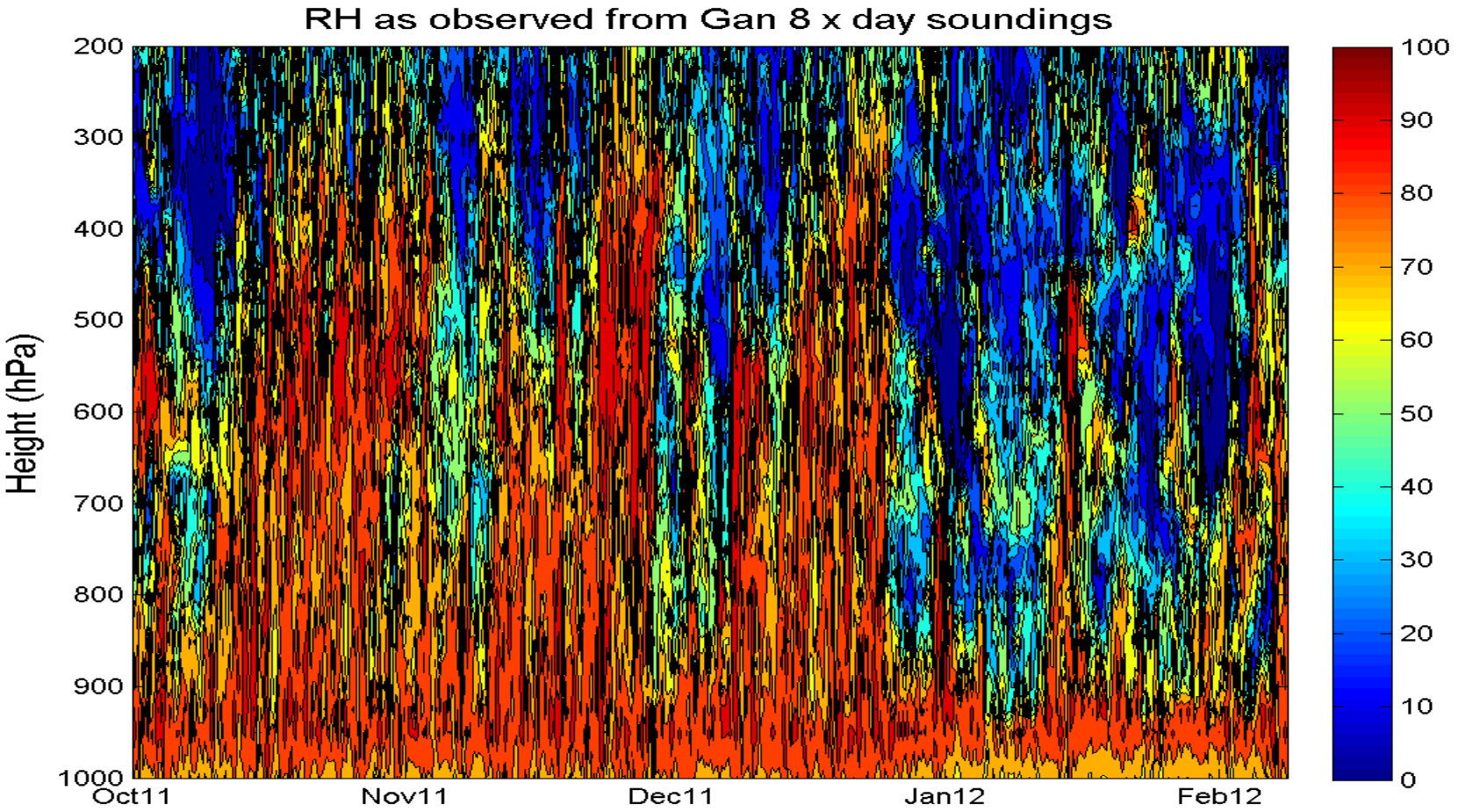
50
60
70
80
90
100
GrADS: COLA/IGES
2013-07-20-14:53

DYNAMO Radiosondes at Gan: Relative humidity

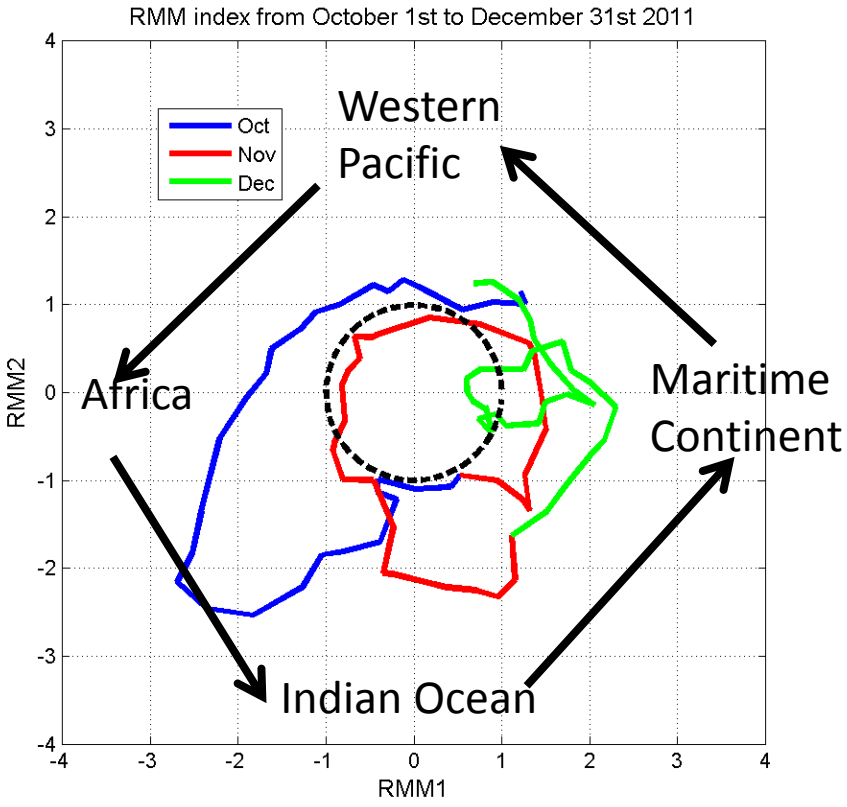


Observations are indicative of a moisture recharge process as in Benedict and Randall (2007)

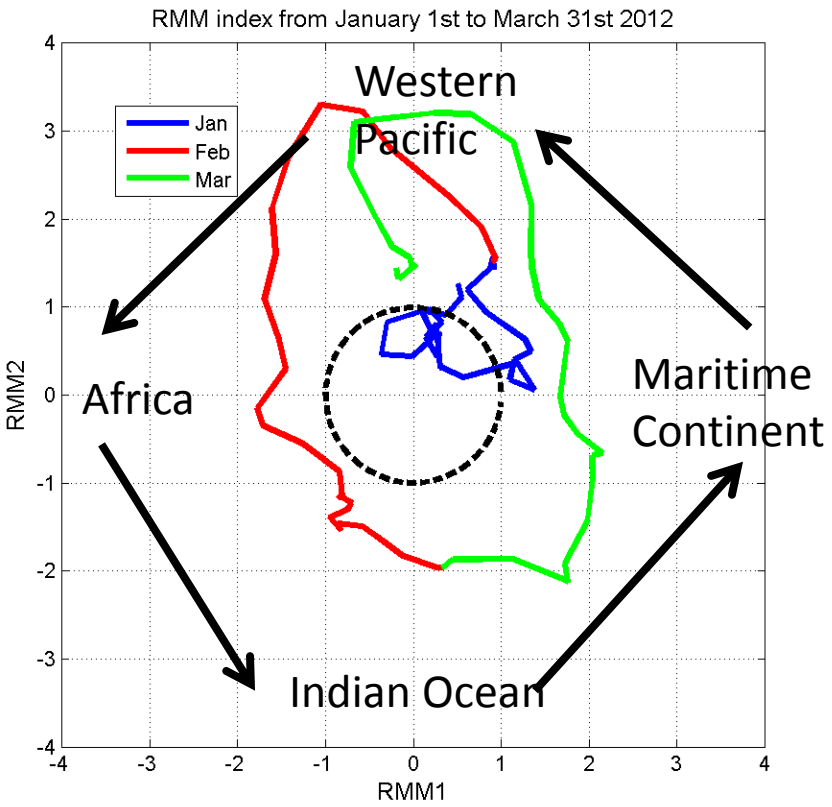
DYNAMO was a lucky campaign!

Review of DYNAMO through the RMM index

October to December 2011



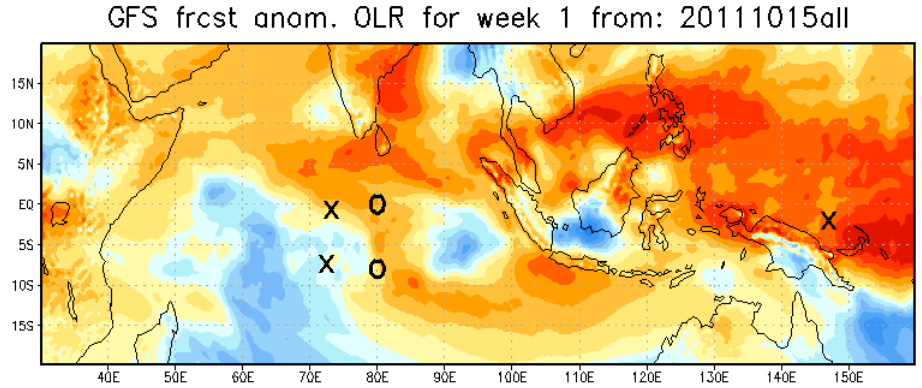
January to March 2012



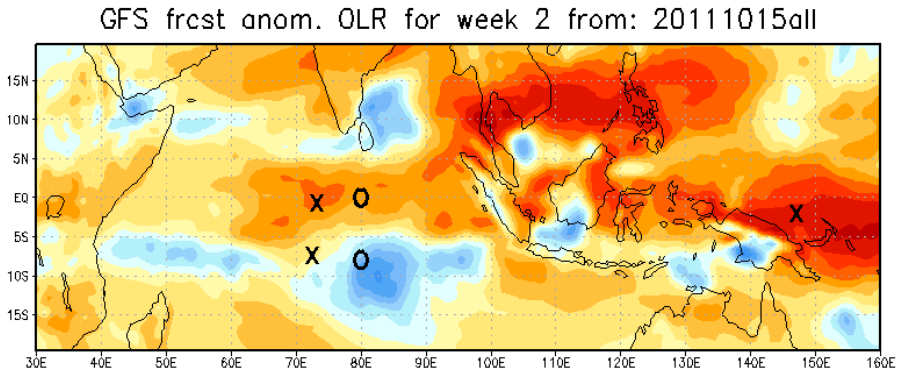
Forecast of Anomalous OLR (GFS) for the first DYNAMO MJO event

Forecast

Week 1



Week 2



Verification